Surface Operations Simulator and Scheduler (SOSS) Presentation

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Incheon International Airport, Incheon, Korea
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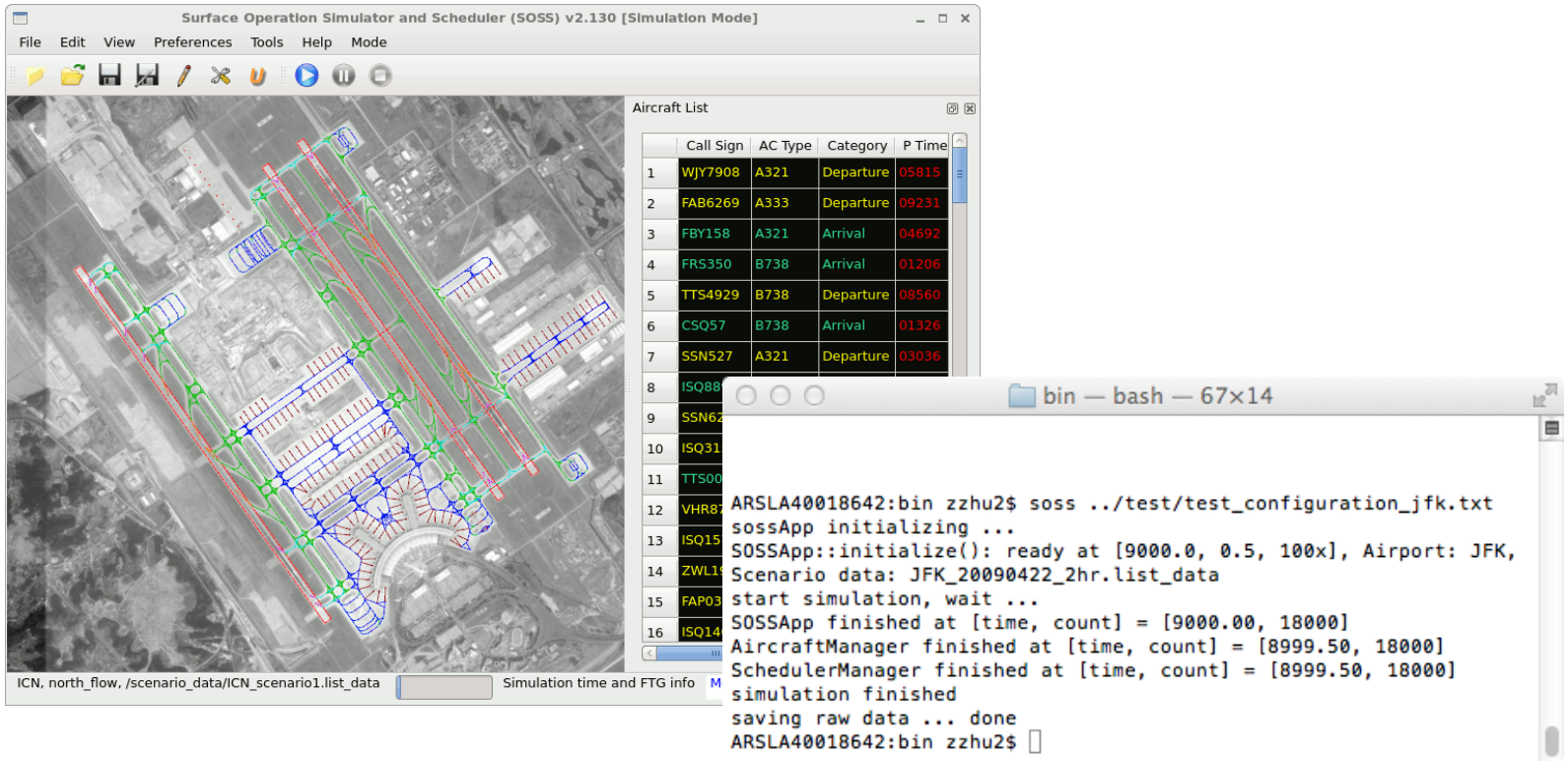
Outline

- What is SOSS?
- SOSS Architecture
- How SOSS Models Airport Surface Traffic
- Build a SOSS ICN model

What is SOSS?

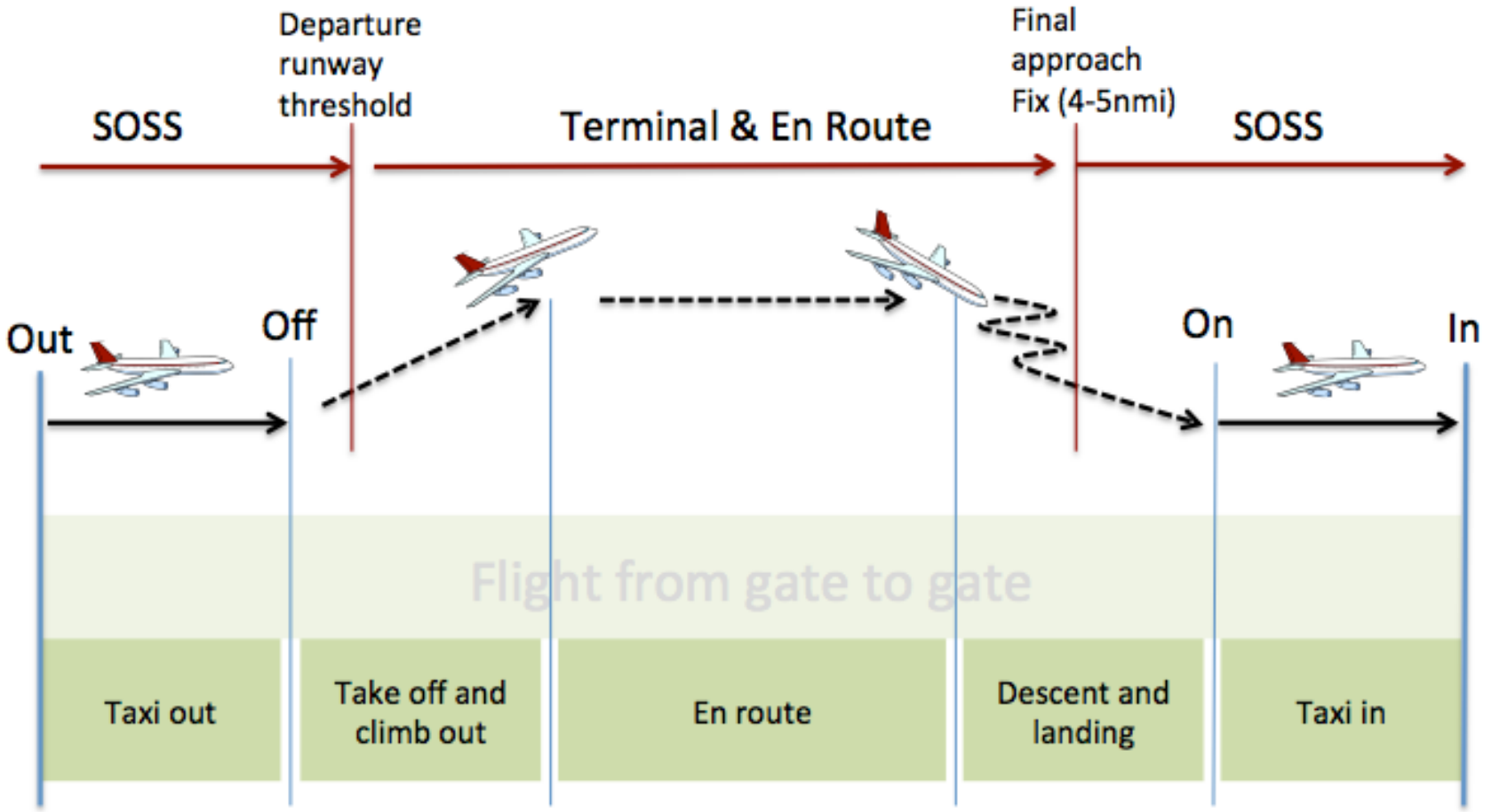
- Fast time simulation tool running on desktop/ laptop computers



What is SOSS: Domain

- Fast time simulation tool running on desktop/ laptop computer
- Manage surface and runway traffic

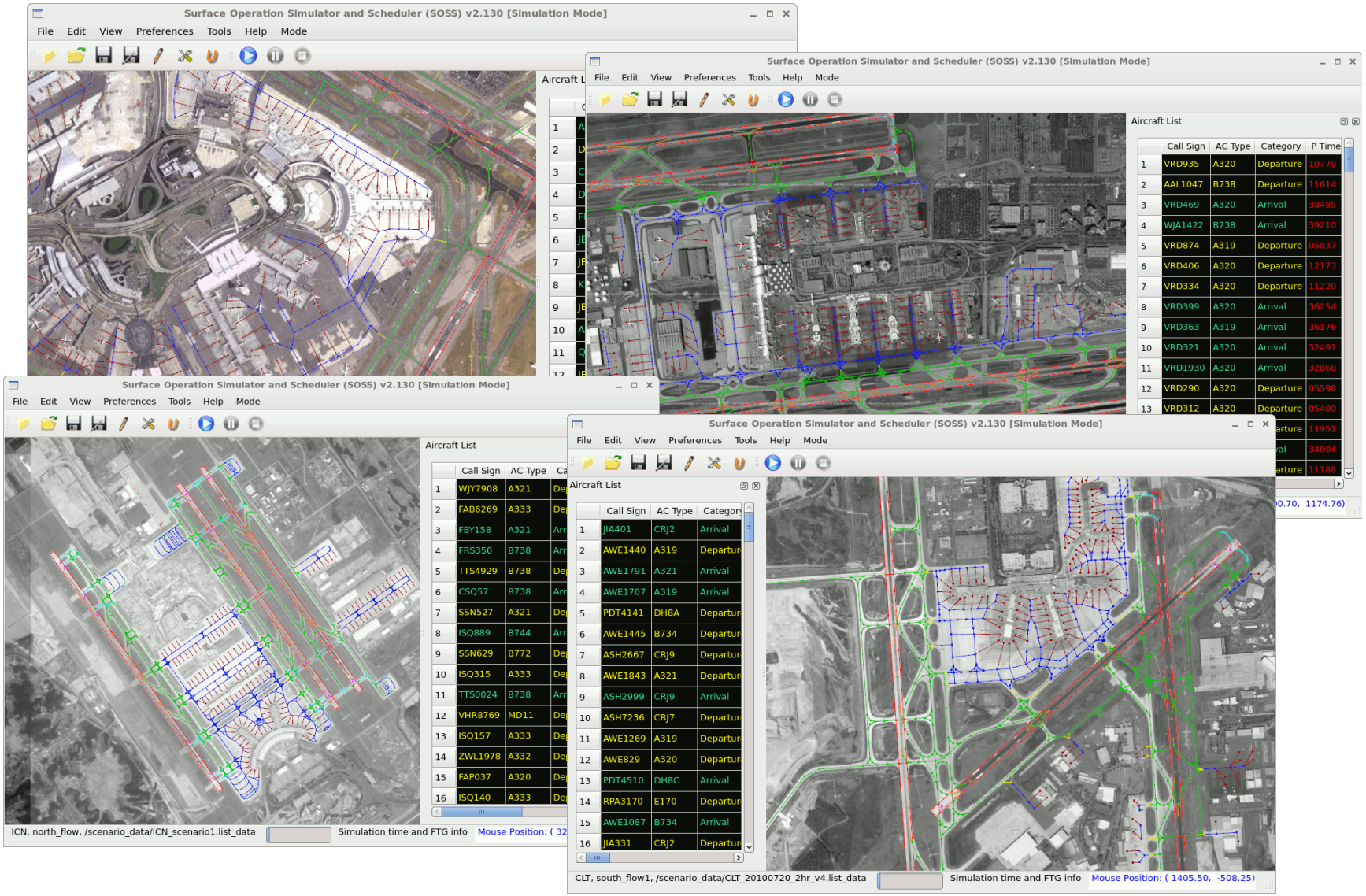
What is SOSS: Domain



What is SOSS: Airport Models

- Fast time simulation tool running on desktop/ laptop computer
- Manage surface and runway traffic
- Airport model independent

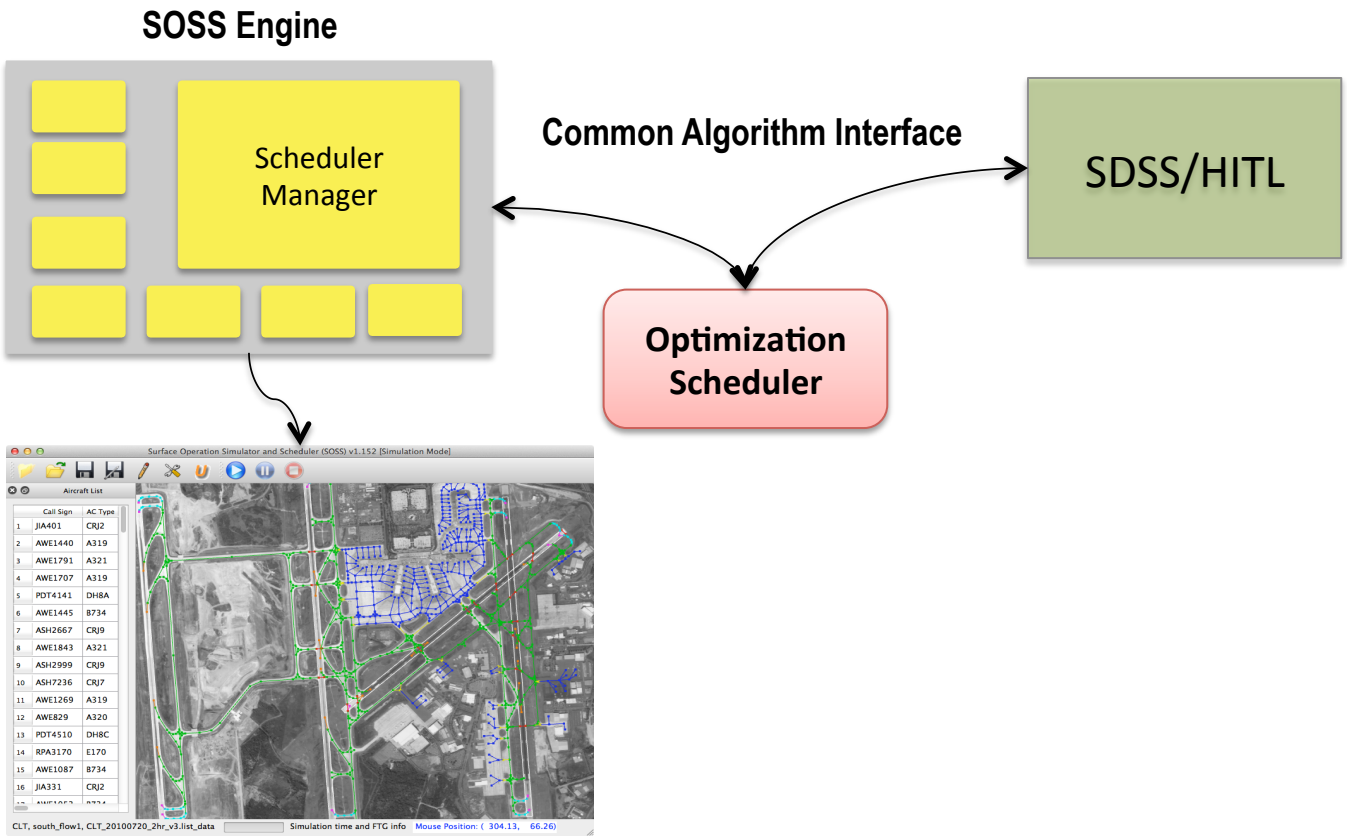
What is SOSS: Airport Models



What is SOSS: CAI Support

- Fast time simulation tool running on desktop/ laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation

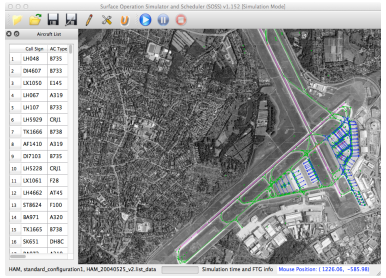
What is SOSS: CAI Support

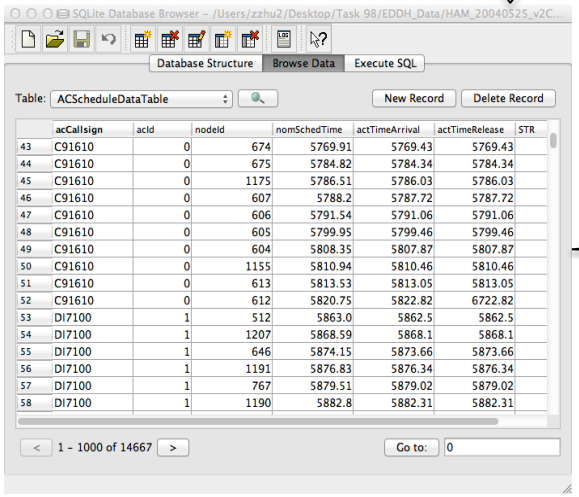


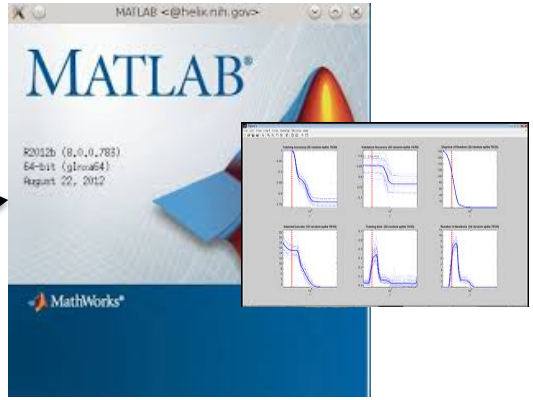
What is SOSS: Output

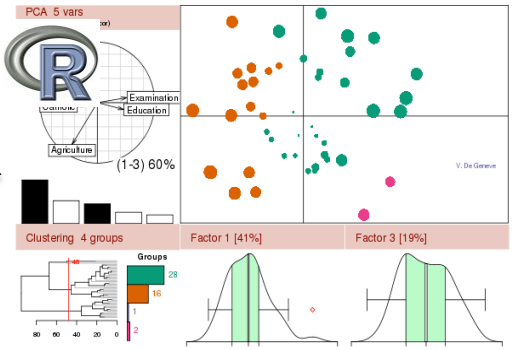
- Fast time simulation tool running on desktop/ laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database

What is SOSS: Output









What is SOSS: Playback

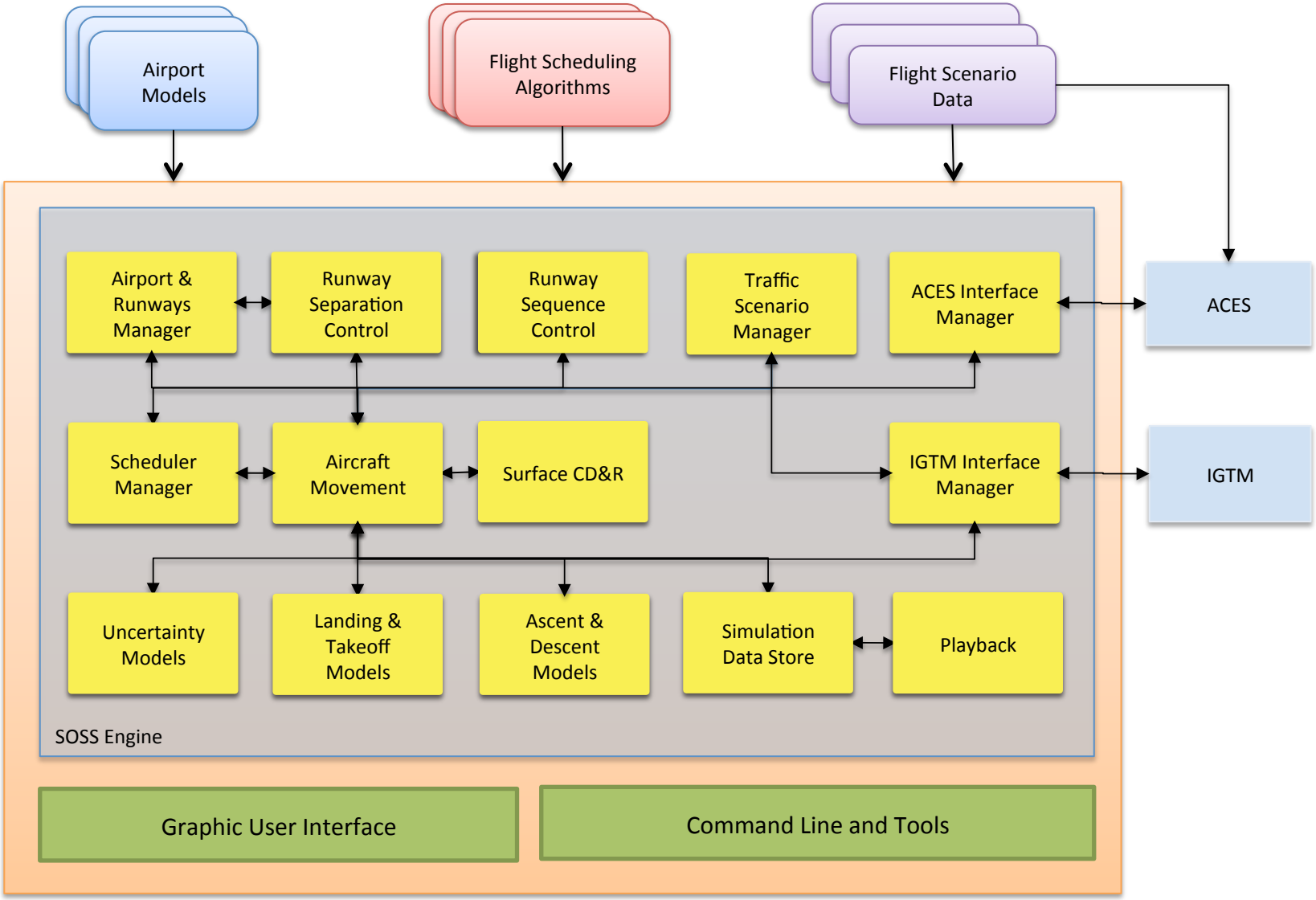
- Fast time simulation tool running on desktop/ laptop computer
- Manage surface and runway traffic
- Airport model independent
- Common interface to scheduling algorithms with human-in-the-loop (HITL) simulation
- Post data analysis on database
- DVR type playback

What is SOSS: Playback

What is SOSS: vs HITL

- Different from HITL environment
  - No human interaction
  - Follow traffic scheduling advisories (best effort)
  - Can run various simulations in a short time
  - Useful for early prototype and adaptation for HITL modeling

SOSS System Architecture



How SOSS Models Airport Surface Traffic

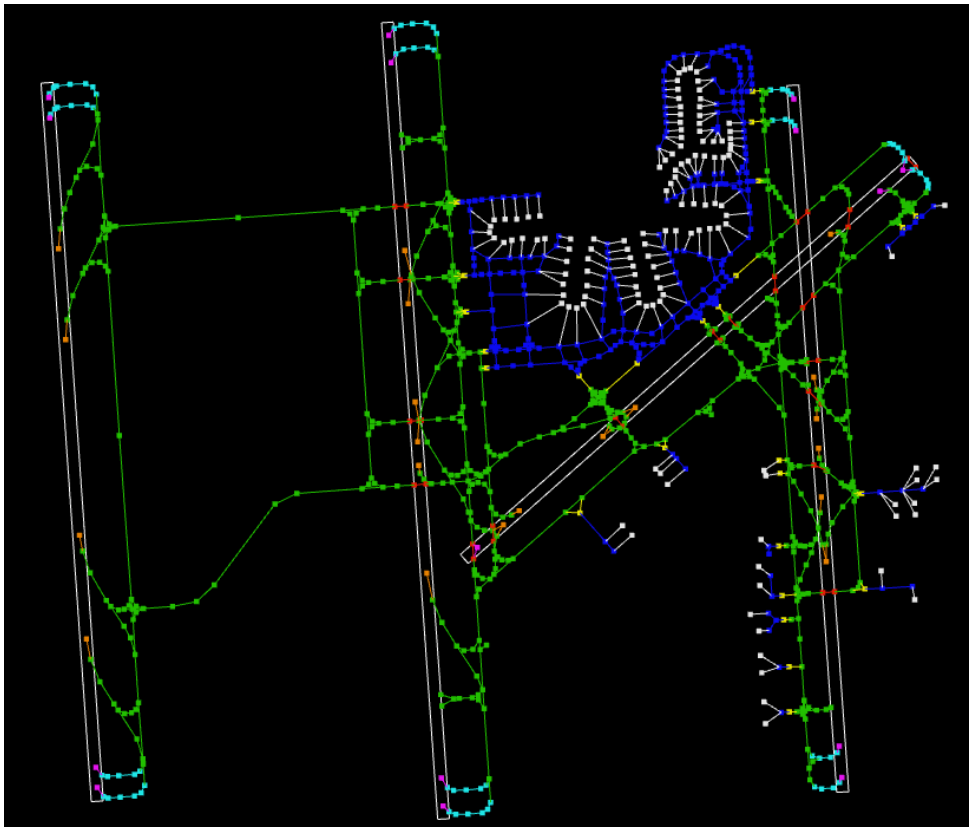
- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler
- Walk through example

How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Surface node-link graph
  - Runway configuration
  - Taxiing routes
  - Weather condition

How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Surface node-link graph



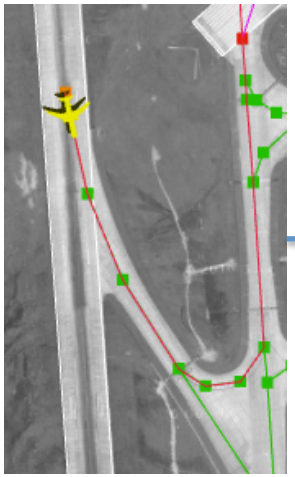
Node-link graph representation of CLT

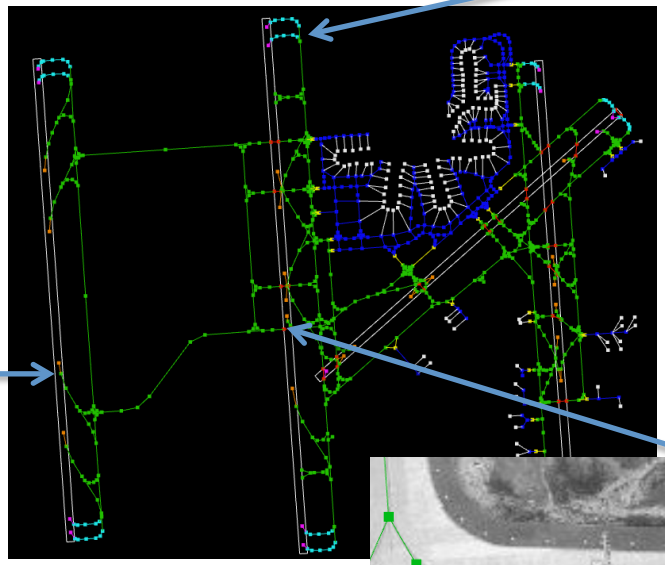
How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Runway configuration
    - Runway geometry, length, heading
    - Takeoff, exit and crossings
    - Traffic flow direction
    - Runway separation rules

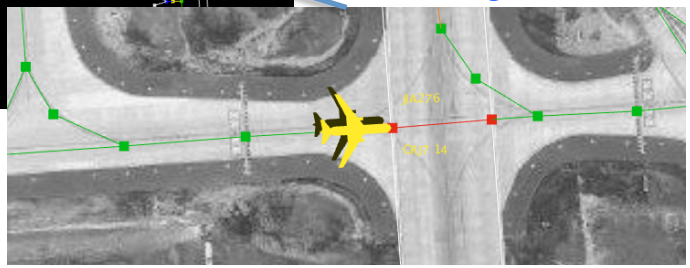
Takeoff position

Runway exit



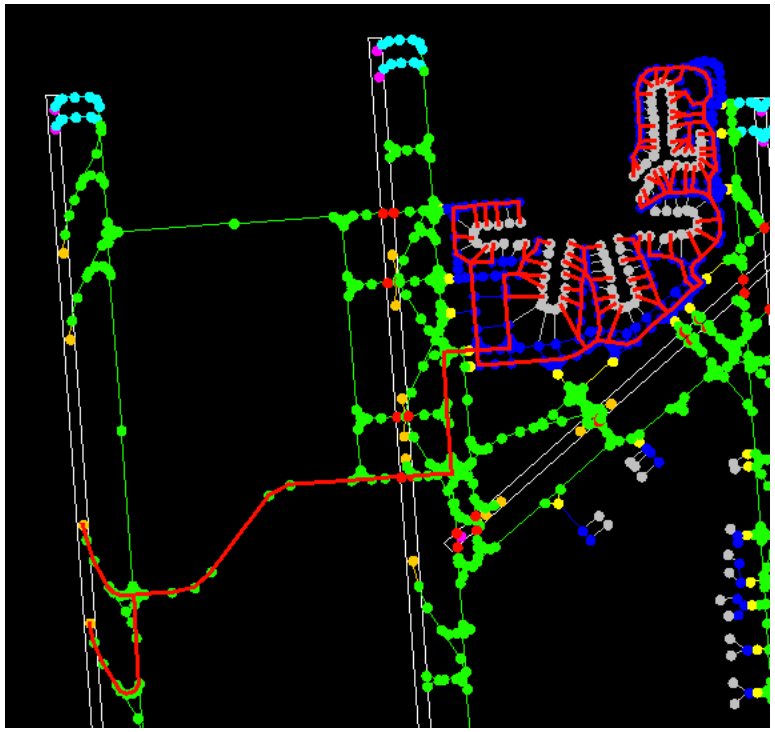


Crossing



How SOSS Models Airport Surface Traffic

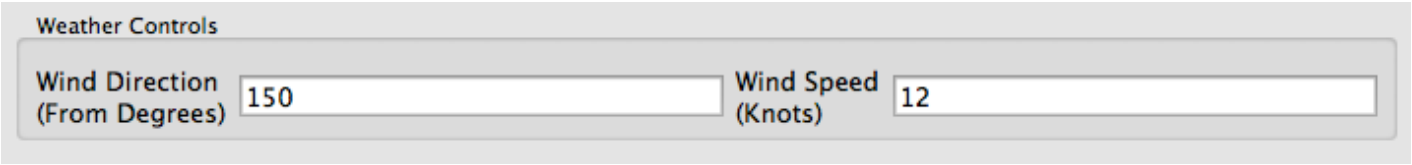
- Airport adaptation
  - Taxiing routes
    - Based on surface operation configurations
    - Static taxiing routes between runways and gates
    - Multiple routes between runway and gate possible



Taxi routes in color codes based on airport geometry categorization

How SOSS Models Airport Surface Traffic

- Airport adaptation
  - Weather condition
    - Currently only static wind (speed and direction) impacting on landing and takeoff

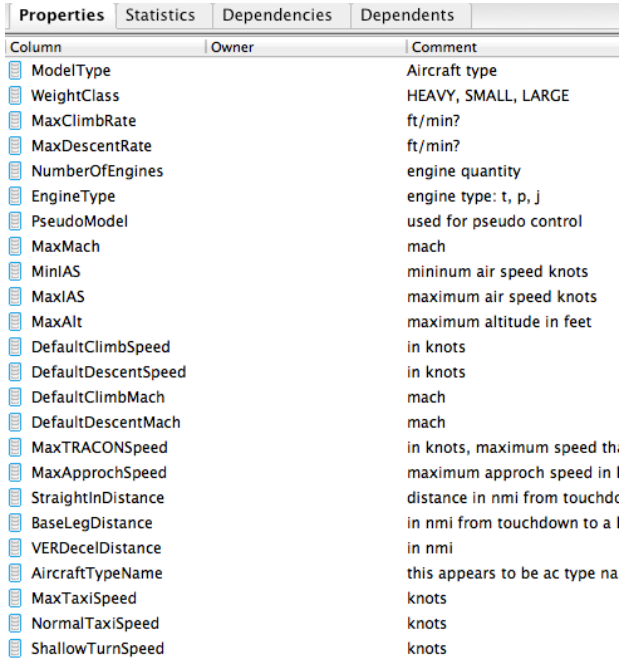


How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
  - Built-in aircraft dynamics database
  - Aircraft taxiing mobility model
  - Separation criteria and surface conflict detection & resolution (CD&R)
  - Uncertainty model for taxi speed and flight readiness (i.e., pushback)

How SOSS Models Airport Surface Traffic

- Surface traffic movement
  - Built-in aircraft dynamics database
    - 459 aircraft types – extensible and substitution-able
    - Each type has 36 aircraft dynamic parameters
    - Weight class: small, large, heavy (, super heavy)



Properties | Statistics | Dependencies | Dependents

Column	Owner	Comment
ModelType		Aircraft type
WeightClass		HEAVY, SMALL, LARGE
MaxClimbRate		ft/min?
MaxDescentRate		ft/min?
NumberOfEngines		engine quantity
EngineType		engine type: t, p, j
PseudoModel		used for pseudo control
MaxMach		mach
MinIAS		mininum air speed knots
MaxIAS		maximum air speed knots
MaxAlt		maximum altitude in feet
DefaultClimbSpeed		in knots
DefaultDescentSpeed		in knots
DefaultClimbMach		mach
DefaultDescentMach		mach
MaxTRACONSpeed		in knots, maximum speed th
MaxApprochSpeed		maximum approch speed in l
StraightInDistance		distance in nmi from touchdo
BaseLegDistance		in nmi from touchdown to a l
VERDecelDistance		in nmi
AircraftTypeName		this appears to be ac type na
MaxTaxiSpeed		knots
NormalTaxiSpeed		knots
ShallowTurnSpeed		knots

Aircraft performance parameters

How SOSS Models Airport Surface Traffic

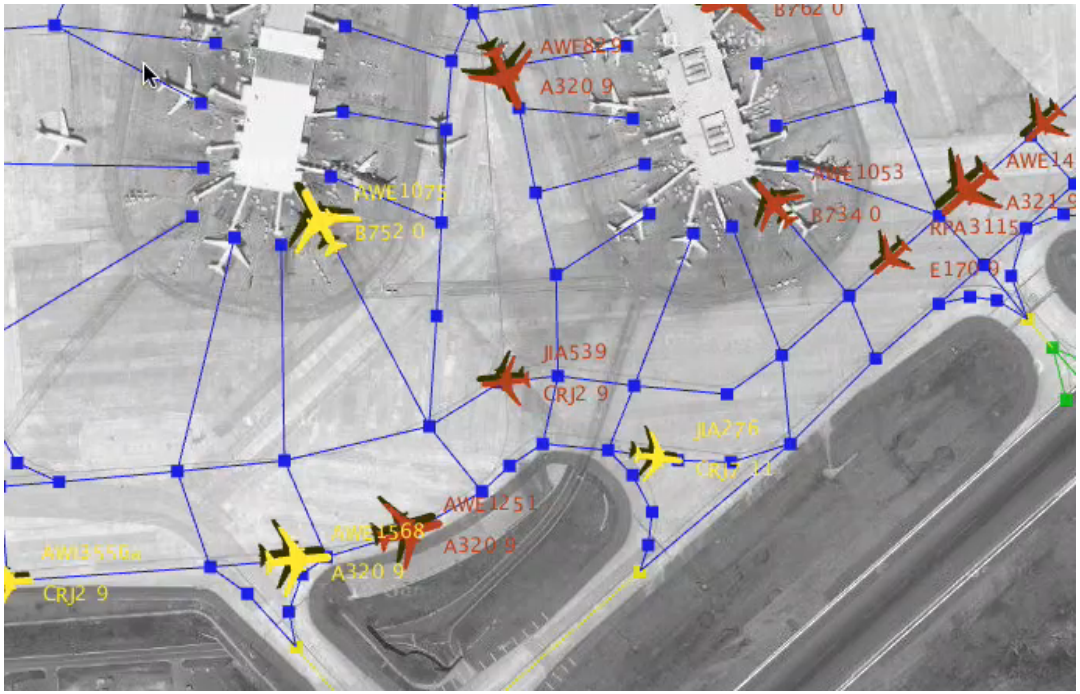
- Surface traffic movement
  - Aircraft taxiing mobility model
    - Aircraft type dependent mobility characteristics – speeds, accel/deccel
    - 'open-loop' movement with linear accel/decel and nominal speed
    - No turn/curve model yet
    - Taxi movement follows node-link along assigned route

Aircraft movement from pushback to takeoff

How SOSS Models Airport Surface Traffic

- Surface traffic movement
  - Separation criteria and surface CD&R
    - Aircraft to aircraft safety separation
    - Conflict detection and FCFS resolution (localized)

Example of taxi separation and surface CD&R in the ramp area

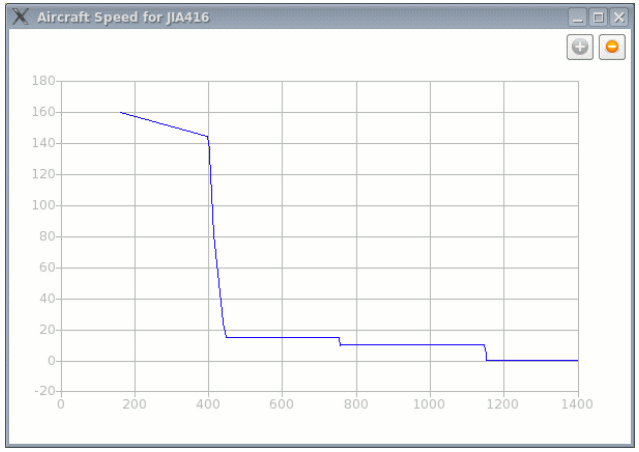


Aircraft movement demonstrating surface CD&R capability

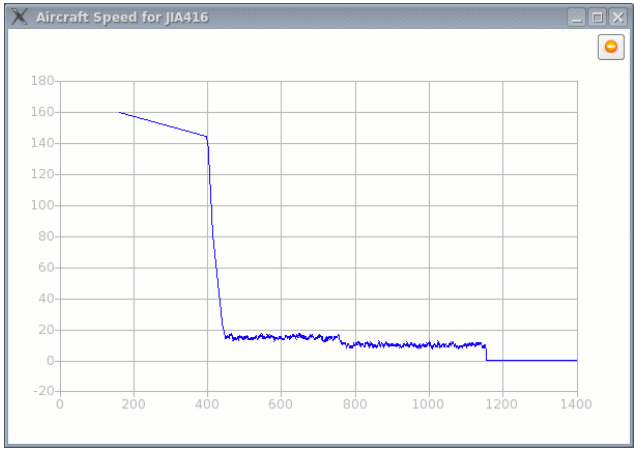
How SOSS Models Airport Surface Traffic

- Surface traffic movement
  - Uncertainty in speed and flight-readiness
    - Individual taxiing speed variation uncertainty
    - Individual flight readiness uncertainty

Uncertainty in flight readiness



No uncertainty in taxi speed



With uncertainty in taxi speed

How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
- Traffic scenarios
  - Static flight schedule scenario – surface only modeling
  - Dynamic flight schedule – terminal space integration

How SOSS Models Airport Surface Traffic

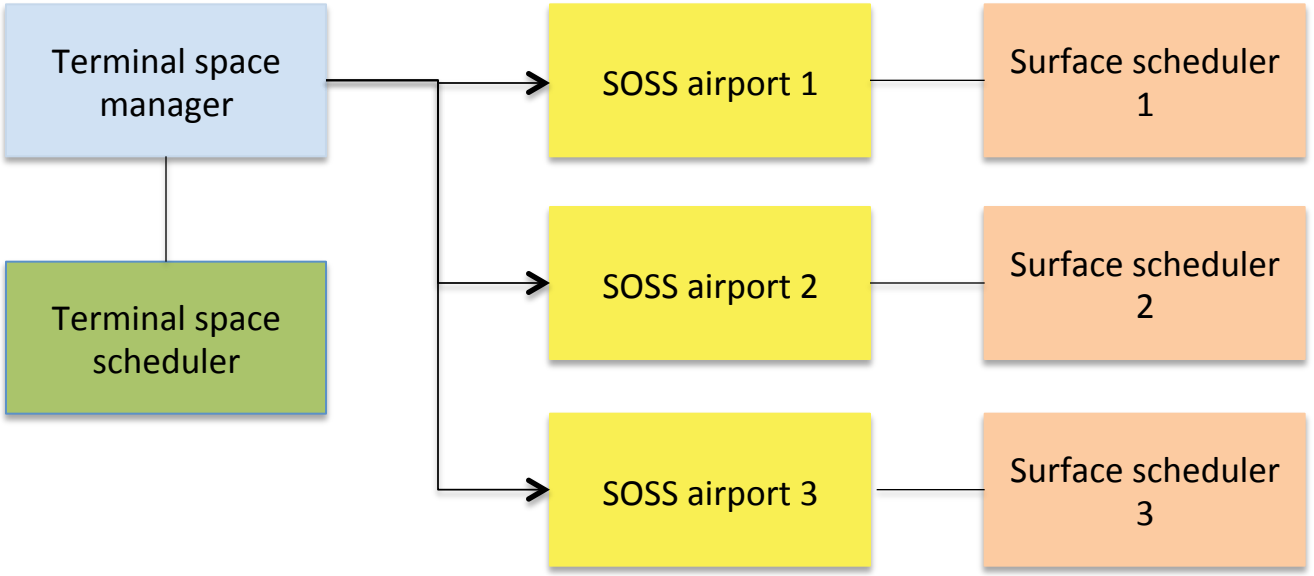
- Traffic scenarios
  - Static flight schedule scenario – surface only modeling
    - Flight ID, aircraft callsign, and aircraft type
    - Runway and gate assignment
    - Gate pushback time (or off block time)
    - Final approach start time
    - Destination airport
    - Tail number

Column	Owner	Comment
flight_id		unique flight id
flight_type		inbound or outbound flight
type		aircraft type that helps determine aircraft characteristics
destination		destination airport for outbound flight
runway		runway assignment
position		usually the gate or stand position
fix		metering fix
tail		turnaround tail number
time		flight schedule time may be wheel on, wheel off, gate off block or in block time

Data elements in traffic scenario

How SOSS Models Airport Surface Traffic

- Traffic scenarios
  - Dynamic flight schedule – terminal airspace integration
    - Allows runtime flight schedule passing to SOSS
    - SOSS handles inbound traffic to gate and handover outbound traffic to a terminal space flight manager
    - Support metroplex simulations



How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
  - Landing and takeoff models
  - Gate management model (a case study in 2015)
  - Other potentials (e.g., de-icing, fuel/emission model)

How SOSS Models Airport Surface Traffic

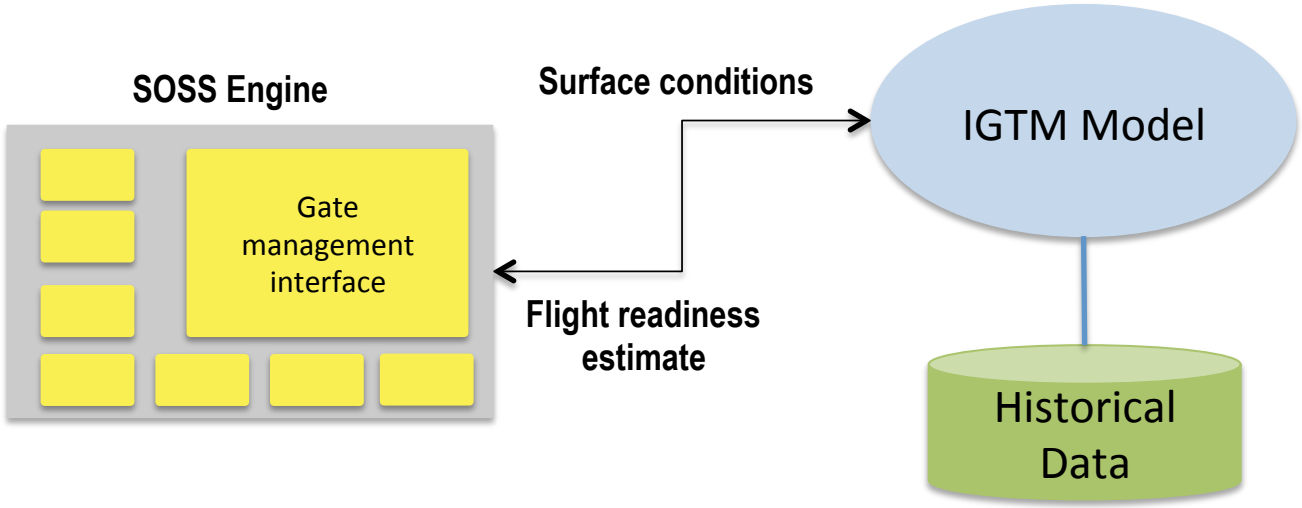
- Model integration
  - Landing and takeoff models – using aircraft dynamics, winds and runway configurations

Landing: runway threshold – wheels on – runway exit

Takeoff: take off accel – wheels off – runway threshold

How SOSS Models Airport Surface Traffic

- Model integration
  - Landing and takeoff models
  - Gate management model (a case study tested in 2015)

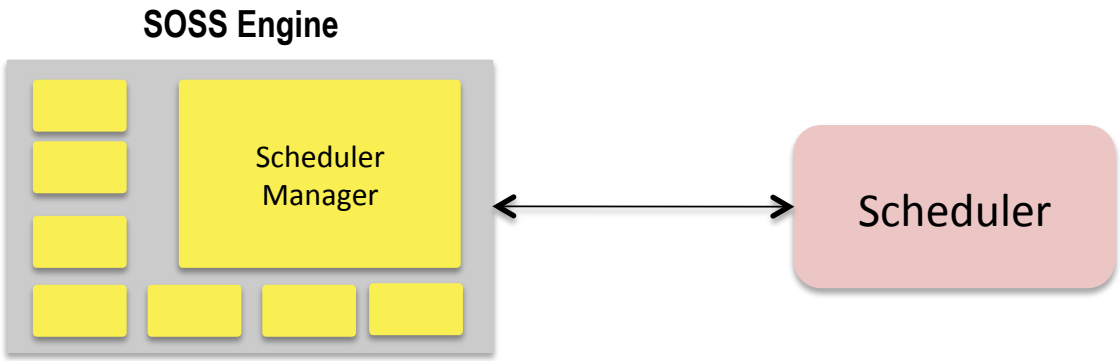


How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler (e.g., SARDA scheduler)

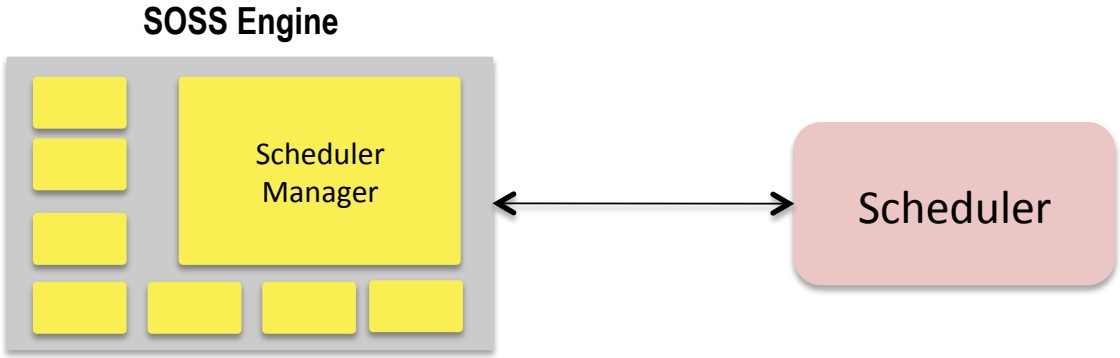
How SOSS Models Airport Surface Traffic

- Connection to scheduler
  - Communication between SOSS and a scheduling algorithm uses a Common Algorithm Interface (CAI) protocol
  - Scheduler call can be synchronized or a-synchronized
  - Multiple schedulers can be connected, e.g., one for each side runways



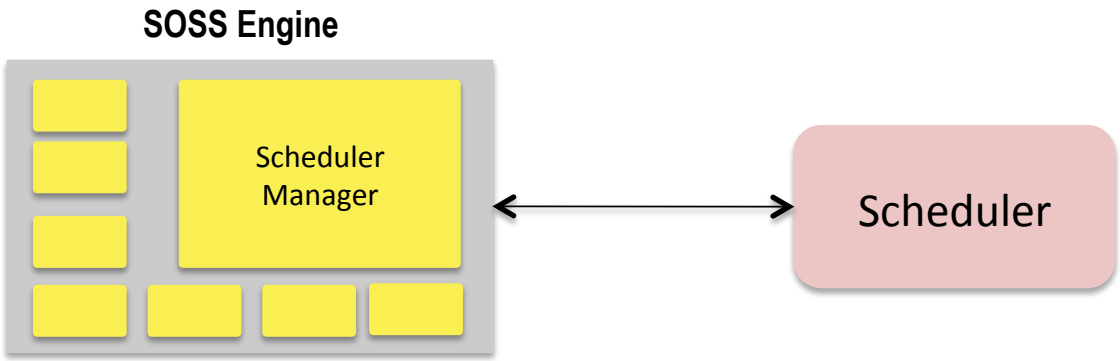
How SOSS Models Airport Surface Traffic

- SOSS to scheduler
  - Runway information: most recent operations (take off, landing, crossing)
  - Departure fix information: most recent fix usage (time, aircraft type, weight class)
  - List of aircraft in planning horizon: current states, predicted times, runway/gate, taxi routes



How SOSS Models Airport Surface Traffic

- Scheduler to SOSS
  - List of aircraft and STRs (scheduled time of release)
  - STRs can be provided at all nodes, but typically at control locations such as gate, spot, etc.
  - A branch of source code in SOSS distribution dedicated to building scheduler with the CAI is available



How SOSS Models Airport Surface Traffic

- Airport adaptation
- Surface traffic movement
- Traffic scenarios
- Model integration
- Connection to scheduler (e.g., SARDA scheduler)
- Walk through example

How SOSS Models Airport Surface Traffic

- Walk through example: departure without a scheduler
  - Initiate departure flights at assigned gates
  - Start push back at scheduled time
  - Follow the default taxi route to assigned runway
  - Aircraft joins traffic to runway queue
  - Enter runway queue in the order of arrival
  - Ready to take off and meet separation rules
  - Takeoff model takes over
  - Runway events (start acceleration, wheels off, threshold crossing) are registered

Build SOSS ICN model

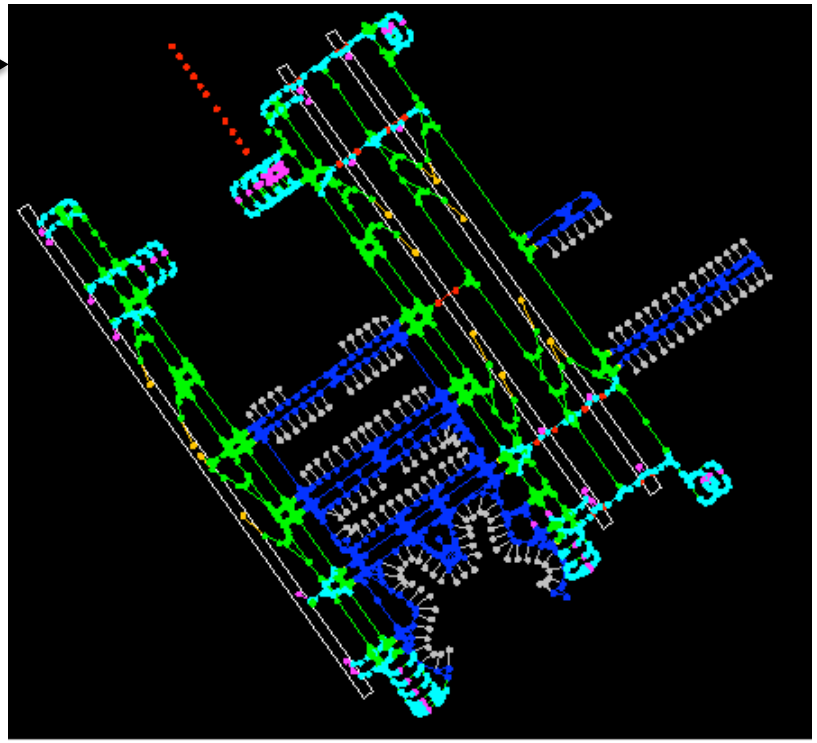
- Build a SOSS ICN model, step by step

Operation Info & historical data

Build SOSS ICN model

- Build a SOSS ICN model, step by step

Operation Info & historical data →



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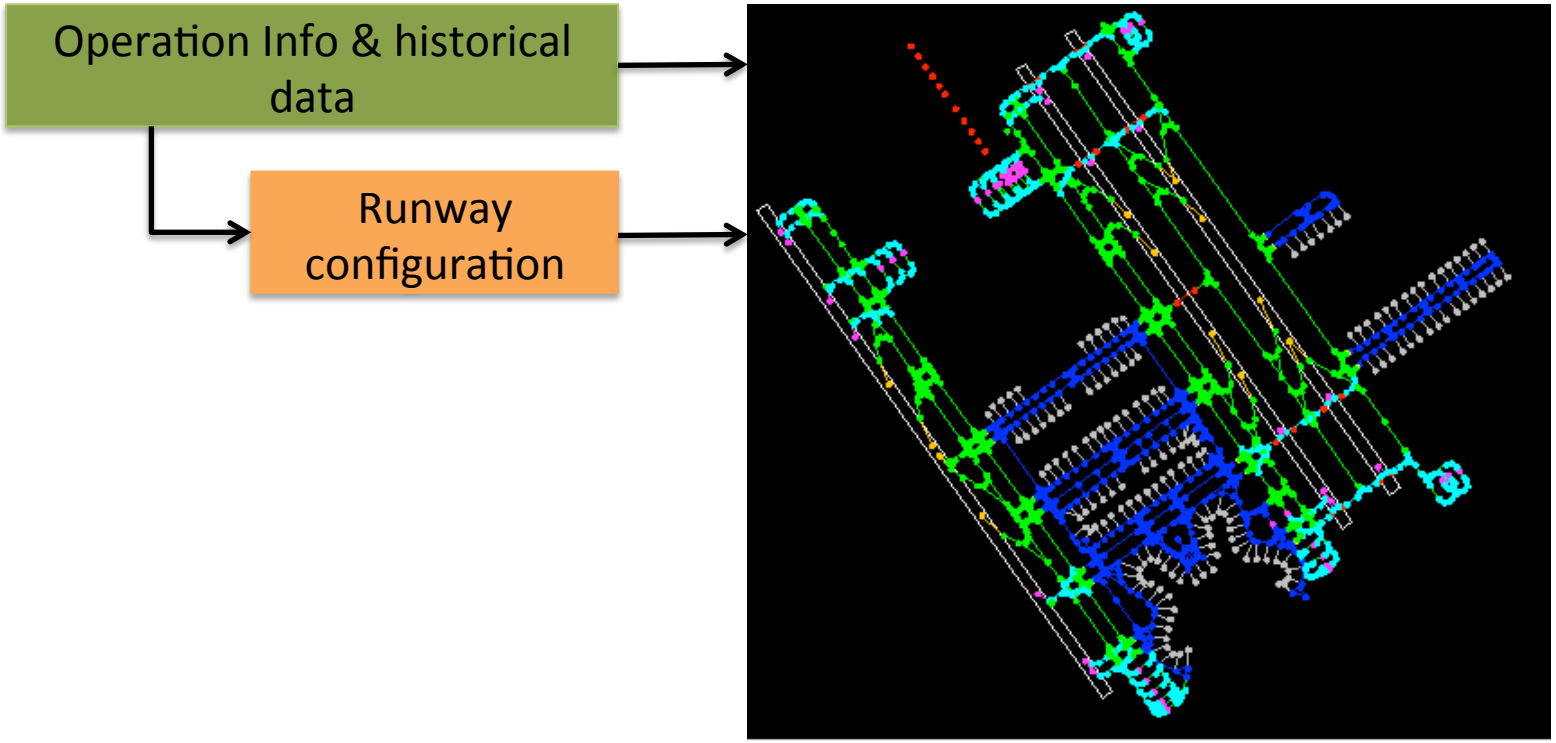

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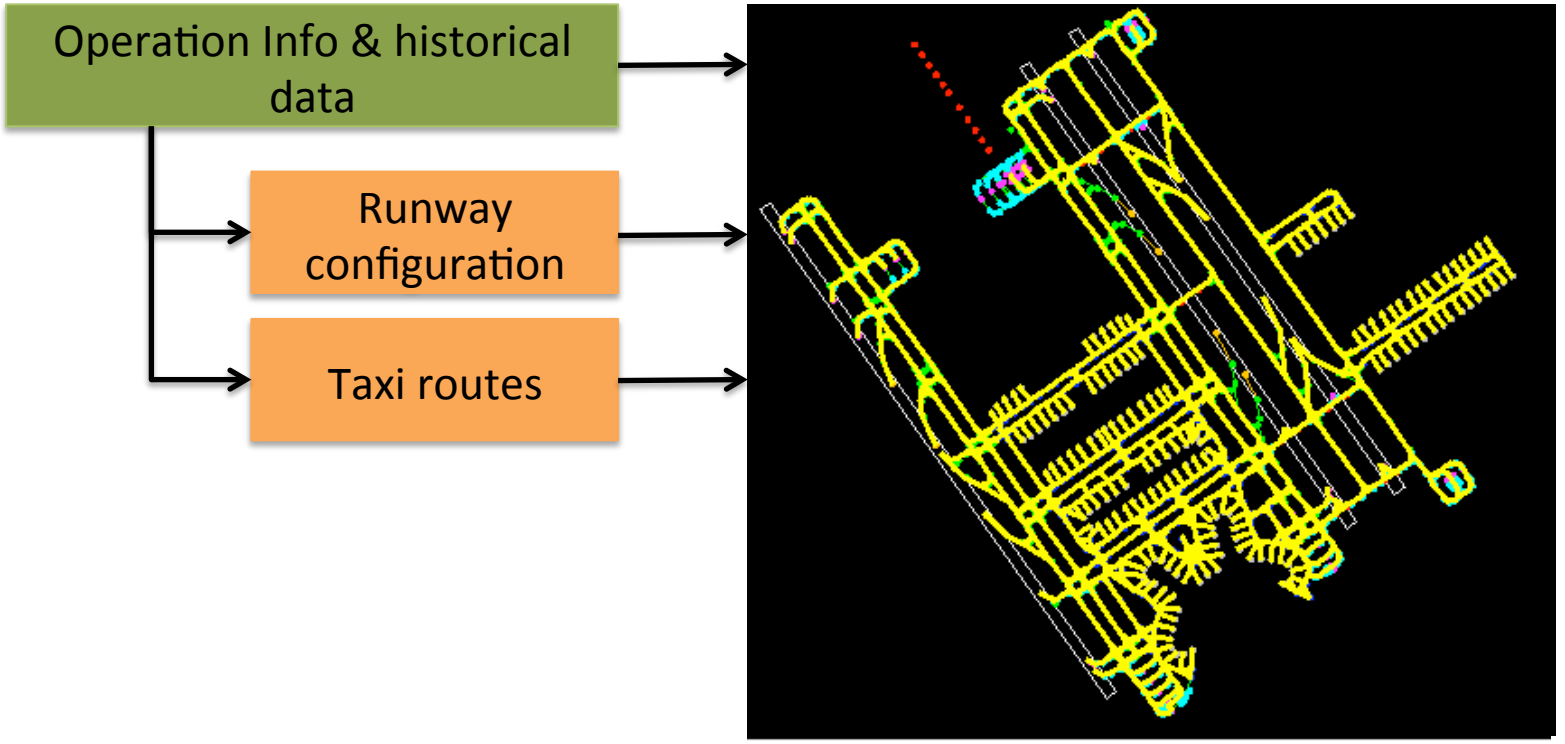

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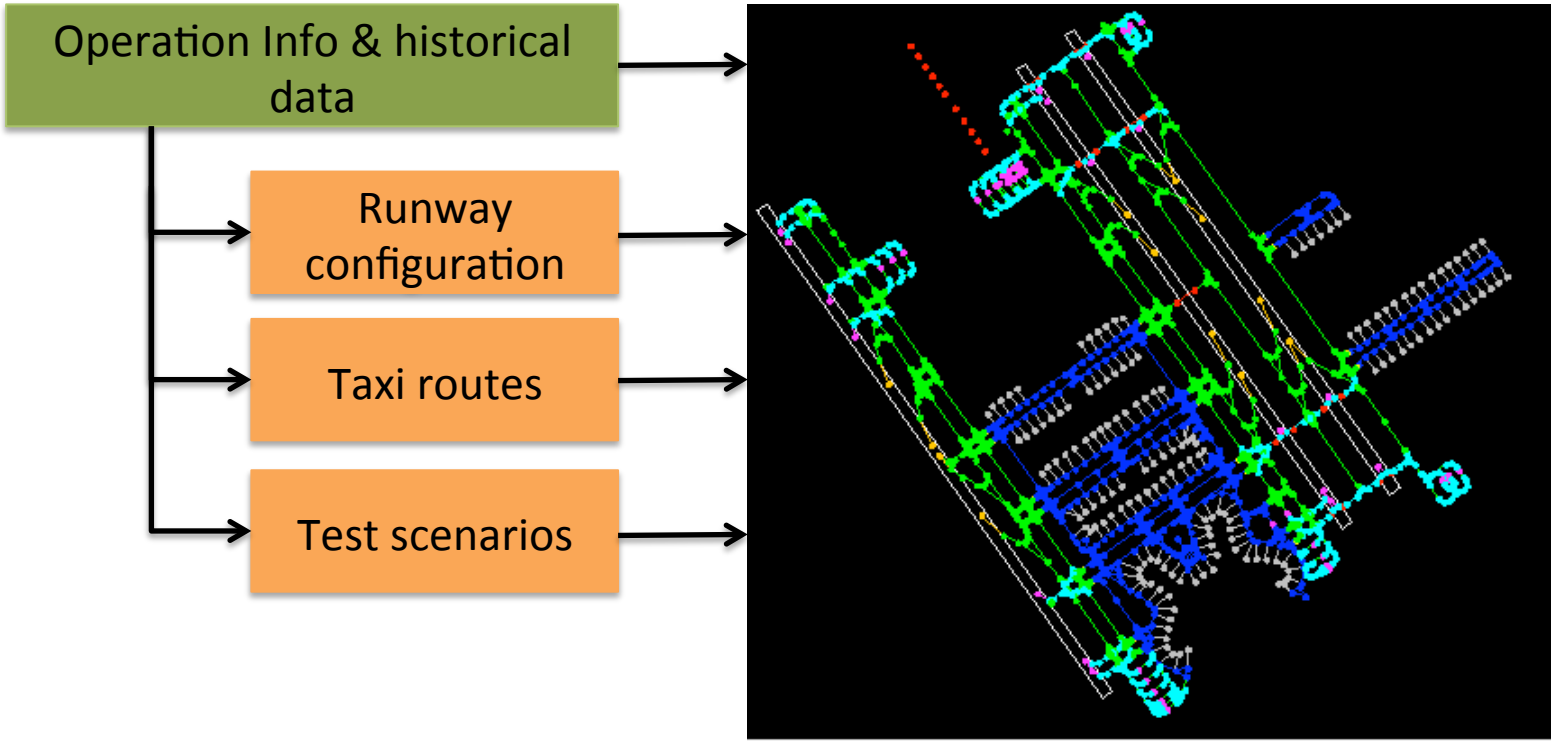

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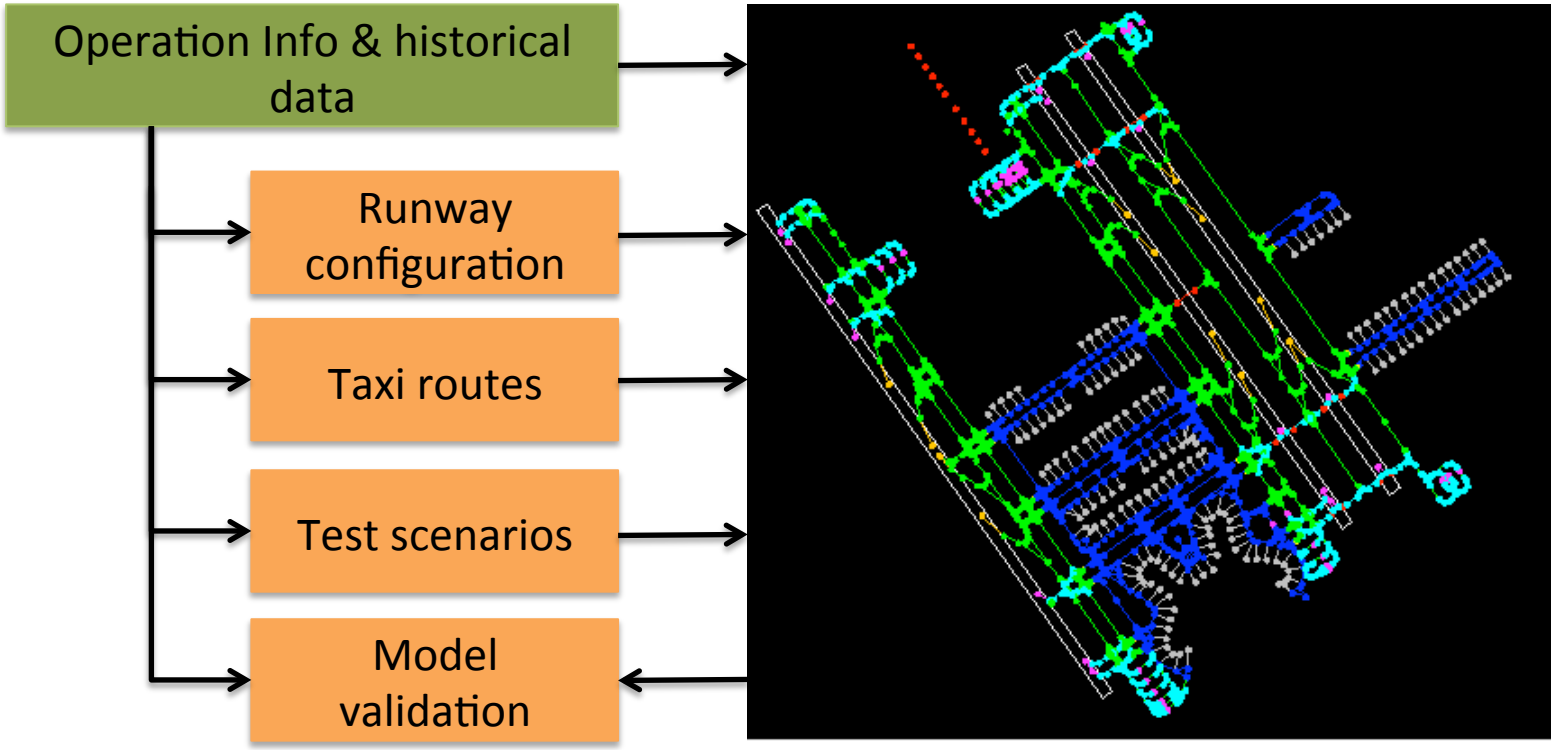

Summary

- SOSS is a fast-time surface traffic modeling and simulation tool for desktop/laptop computer
- Allow building of airport adaptation model, shared with HITL simulation environment
- Use the same interface (i.e., CAI) to surface scheduling algorithm as the real-time environment
- Help build early prototype decision support tools and evaluation of scheduling algorithms
- Has a modular architecture for model/component integration
- Provide a complement surface modeling and simulation capability to HITL simulation

Questions?